**Dry Lab: Comparing Mitosis and Meiosis**

**Learning goals:**

-to identify cells in the different stages of mitosis

-to experimentally determine in which stage the cell spends most of its time

-to describe the different stages of mitosis

-to compare cytokinesis in plant and animal cells

-to view and describe the stages of meiosis

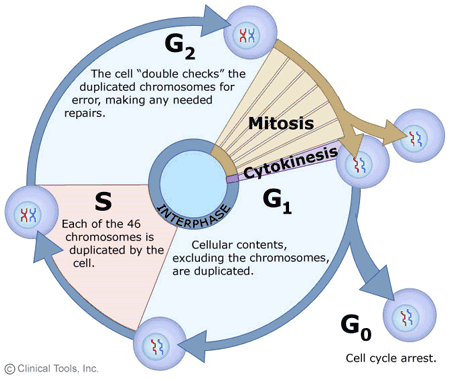
-to describe how crossing over contributes to genetic variability

-to compare and contrasts mitosis and meiosis processes

-to learn vocabulary associated with these processes (*meiosis, mitosis, cytokinesis, somatic cells, germ cells, chromosome, centrioles, centromere, spindle fibers, chiasmata, homologous chromosomes, crossing over, gene)*.

**Introduction:**

In 1858, Rudolf Virchow discovered that new cells can only arise from previously existing cells. There are two processes that give rise to new cells: mitosis and meiosis. Somatic (body) cells divide exclusively by mitosis (division of nuclear material) followed by splitting of the cytoplasm and organelles, called cytokinesis. Meiosis is the process through which specialized germ cells produce gametes (sex cells).

**PART I. MITOSIS**

Before mitosis occurs, the cell must duplicate all of its genetic material. This occurs during interphase (*refer to the Cell Cycle diagram on the right*).

Mitosis is a continuous process, but can be divided into four major phases: prophase, metaphase, anaphase, telophase.

1. **Stages of Mitosis**

Briefly describe what happens in each stage, using the space and diagrams on the next page (*please, use your textbook for help*).

|  |  |
| --- | --- |
| **Mitosis.jpgProphase** | *-nuclear membrane breaks down*  *-chromosomes shorten and thicken (to form two chromatids attached at the centromere)*  *-mitotic structures begin to form (e.g. spindle fiber apparatus)*  *-in animal cells, centrioles form* |
| **Mitosis.jpgMetaphase** | *-chromosomes are now lined up along the equator of the cell*  *-spindle fibers attach to the centromeres of chromosomes* |
| **Mitosis.jpgAnaphase** | *-chromosomes are separated by the pulling of the spindle fibers*  *-chromosomes are moving to opposite poles of the cell* |
| **Mitosis.jpgTelophase** | *-chromosomes are now at the opposite poles of the cell*  *-mitotic structures (e.g. centrioles) begin to break down*  *-nuclear membrane begins to form around each set of chromosomes* |

*Note: The diagrams above represent phases of animal meiosis.*

**2. Observing Mitosis in Plant Cells under the Microscope**

Materials:

-microscope

-prepared microscope slide of onion root tip mitosis

Procedure:

1. Turn on the microscope. Make sure it is set to the lowest power.
2. Place the microscope slide on the stage.
3. Observe the onion root tip, first at 100X, then at 400X.
4. Identify the cells which represent each mitotic phase. Draw each phase of plant cell mitosis that you see below (*please, label each phase)*.

|  |  |  |  |
| --- | --- | --- | --- |
| Prophase | Metaphase | Anaphase | Telophase |

1. Examine at least 3 *different* fields of view at 400X magnification. (*Make sure that none of the fields of view overlap!).* For each field of view, **count** the number of cells in interphase and each phase of mitosis. Record your observations in the table below.
2. Calculate the **total** number of cells counted. Then, calculate the **percent** of total number of cells for interphase and each phase of mitosis. Record in the table on page 4.

Total # of Cells (for all 3 fields of view): \_\_\_\_\_\_\_\_

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | # of cells in Field 1 | # of cells in Field 2 | # of cells in Field 3 | % of Total # of Cells |
| Interphase |  |  |  |  |
| Prophase | *Answers may vary. Make sure the % calculations are correct.* |  |  |  |
| Metaphase |  |  |  |  |
| Anaphase |  |  |  |  |
| Telophase |  |  |  |  |

Analysis Questions

1. a) Using the information in the table above, determine which phase takes the *longest* for the cell to complete. Explain.

b) Sketch a pie graph of the percentage of cells in each phase to support your answer in part a).

*The longest phase for the cell to complete is* ***interphase****.*

*Pie graphs may vary. Double check if pie graph matches the numbers in table above. Interphase should take up the largest piece of the pie graph.*

1. What is the relationship between the process of mitosis and cytokinesis?

*Mitosis refers to the division of the nuclear material (chromosomes) of a cell. Cytokinesis refers to the division of the cytoplasm and organelles. Cytokinesis always comes after mitosis.*

1. What are the primary differences between cell division in plants and mitosis in animals? (Name at least 2 differences).

*-Mitosis in animals involves the centrioles that “send out” spindle fibers to attach to chromosomes. Plants cells do not have centrioles.*

*-Cytokinesis in plant cells involves formation of a cell plate, while animal cells divide by pinching a furrow.*

**PART II. MEIOSIS**

Meiosis is a process of nuclear division that occurs only in specialized *germ cells*. The end products of meiosis are sex cells, called *gametes* (eggs and sperm in animals). Gametes have **half** the number of chromosomes (*haploid)* compared to a somatic cell (*diploid*). The daughter cells of meiosis are also genetically different from parent cells due to crossing over and random assortment that occur in meiosis I.

Meiosis consists of two divisions, Meiosis I and Meiosis II, which are further subdivided into four phases (prophase, metaphase, anaphase and telophase). Meiosis can produce up to four daughter cells.

One of the sex organs in a lily flower is the anther. Each anther has two pairs of microsporangia (“pollen sacs”), which produce pollen, containing sperm cells. The process of meiosis can be observed in cells of microsporangia.

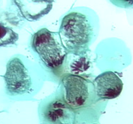
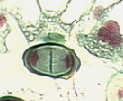
*anther*

*microsporangia*

Process:

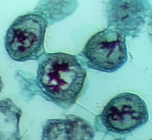
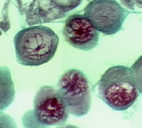
The cross-section of a lily anther (*see below*) is in the early stages of meiosis.

1. Identify the stages of Meiosis I the cells are in (prophase I, metaphase I, anaphase I, telophase I or interkinesis). Briefly explain what happens in each stage. [*Note: one stage is represented twice. You may include* ***one*** *description of what happens.*]



**C**

**A**



**B**



**D**

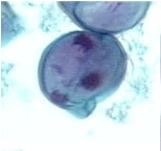
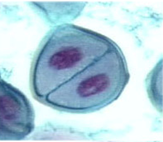
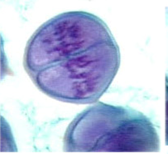
**E**

**F**

|  |  |  |
| --- | --- | --- |
| Diagram | Phase of Mitosis I | What happens? |
| A | *Anaphase I* | *-spindle fibers pull chromosomes toward opposite poles of the cell. The homologous pairs are now broken up.* |
| B | *Metaphase I* | *-homologous chromosomes are now lined up along the equator of the cell*  *-spindle fibers attach to the centromeres of one chromosome in each homologous pair* |
| C | *Interkinesis* | -*the cytoplasm is divided into two separate cells*  *(Note: this division is not equal in oogenesis; most of the cytoplasm and organelles goes to one cell; the other becomes a polar body).* |
| D | *Prophase I* | *-nuclear membrane breaks down*  *-chromosomes shorten and thicken (to form two chromatids attached at the centromere)*  *-mitotic structures begin to form (e.g. spindle fiber apparatus); in animal cells, centrioles form*  *-later in prophase I, homologous chromosomes pair up; crossing over (exchange of genetic information) occurs at the chiasmata (site where chromatids of homologous chromosomes overlap)* |
| E | *Telophase I* | -*chromosomes arrive at different poles of the cell*  *-nuclear membrane may form again* |
| F | *Prophase I* | *n/a (see “D”)* |

In Meiosis II, all the cells in a microsporangium are *not* in the same stage of division. Therefore, images of single cells have been taken for identification of these stages (*see next page)*.

1. Identify the stages of Meiosis II the cells are in (prophase II, metaphase II, anaphase II, telophase II or cytokinesis). Briefly explain what happens in each stage. [*Note: some stages are represented more than once. You may include* ***one*** *description.*]

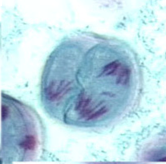


**B**

**C**



**A**

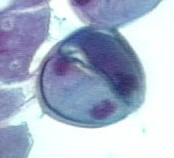


**E**

**D**

**F**

**F**



**I**

**H**

**G**

|  |  |  |
| --- | --- | --- |
| Diagram | Phase of Mitosis II | What happens? |
| A | *Telophase II* | -*the chromatids arrive at each pole of the cell*  *-nuclear membrane forms around each set of chromosomes* |
| B | *Metaphase II* | *-chromosomes align along the equator of the cell*  -*spindle fibers attach to the centromeres of chromosomes* |
| C | *Prophase II* | -*chromosomes condense*  *-spindle apparatus is formed (and centrioles in animal cells)*  *-nuclear membrane disintegrates*  *Note: there is NO exchange of genetic material between chromosomes* |
| D | *Anaphase II* | *-spindle fibers pull the chromosomes apart*  -*chromatids are pulled towards opposite poles of the cell* |
| E | *Cytokinesis* | *-the cytoplasm divides*  -*at the end of meiosis II, four daughter cells are formed*  *(Note: in oogenesis, one viable egg and three polar bodies are formed)* |
| F | *Anaphase II* | *-n/a (same as “D”)* |
| G | *Metaphase II* | *-n/a (same as “B”)* |
| H | *Prophase II* | *-n/a (same as “C”)* |
| I | *Telophase II* | *-n/a (same as “A”)* |

Analysis Questions

1. Compare the processes of meiosis I and meiosis II. How are they different and how are they similar? (Make at least 4 comparisons).

*-Both processes have similar stages: prophase, metaphase, anaphase and telophase.*

*-Both processes are followed by a division of the cytoplasm, called interkinesis or cytokinesis.*

*-There is a duplication of DNA before meiosis I, but not before meiosis II.*

*-There is a re-arrangement of genes in prophase I during crossing over. There is no such process in meiosis II.*

1. Why is meiosis important for sexual reproduction?

*Meiosis is important for sexual reproduction because it ensures genetic variability from one generation to the next. Meiosis is also necessary for a reduction in the number of chromosomes in the gametes by half. Thus, two haploid gametes can come together and make a diploid zygote, which will give rise to diploid somatic cells through mitosis.*

1. List three major differences between the events of mitosis and meiosis.

*-Meiosis involves a re-arrangement of genes on chromosomes resulting in daughter cells that are not identical to the parent cell. Mitosis produces genetically identical daughter cells.*

*-Meiosis involves a reduction in the number of chromosomes by half. Mitosis maintains the same number of chromosomes in daughter cells as the parent cell.*

*-Meiosis occurs only in specialized germ cells. Mitosis occurs in all body cells.*

*-Meiosis involves two divisions, while mitosis involves only one division.*

1. Compare mitosis and meiosis, by filling in the table below.

|  |  |  |
| --- | --- | --- |
|  | **Mitosis** | **Meiosis** |
| Chromosome number of parent cells (in humans) | *46* | *46* |
| Number of DNA replications | *1* | *1* |
| Number of divisions | *1* | *2* |
| Number of daughter cells produced | *1* | *up to 4* |
| Chromosome number of daughter cells | *46* | *23* |
| Purpose/function | *-repair*  *-growth* | *-production of gametes (sperm and egg in humans)* |